

THE FOCUS ON SCIENTIFIC ACTIVITY¹

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The idea that scientific research and higher education are necessarily linked together is widespread. The relationship is seen as basic in the formation of educational policies in many countries. A classical version of this idea has been stated by Talcott Parsons, who believes that the modern scientist has a social place similar in many ways to the position of the humanistic scholar in the early universities. For Parsons, the scholar was "the precursor of the scientist and is of course today his colleague in the most highly educated sector of the population." Both embody a common tradition of scholarship and respect for impartial objectivity and evidence, a tradition that is characteristic of Western culture. "In the most modern era, this cultural tradition has above all become embodied in the university as its principal institutionalized frame".²

¹ I am grateful to Roger Geiger, Morizaku Ishiogi, Edmundo Campos, and Burton R. Clark for their comments and criticism, some of which I was able to incorporate.

² Parsons, "The institutionalization of Scientific Investigation," from *Social System*, 1951, in Barber and Hirsch, *Sociology of Science*, pp.12, 13.

A more modern version of this linkage places the university fully within the technological revolution of our times. "Throughout the period of emerging industrialism in Europe and America," states A. H. Halsey,

The principal function of the universities has been that of status differentiation of elites with some assimilation of students from the lower strata. But the progressive secularization of higher learning since medieval times has increased the potential of the universities as sources of technological and therefore of social change until now they are beginning to occupy a place as part of the economic foundation of a new type of society... Both as research organizations and training establishments, the institutions of higher education in this period have been drawn more closely to the economy either directly or through the state... The exchange of ideas, people and contracts between university departments and research institutes and their counterparts in private industry and government agencies is such as to merge these organizations and to assimilate the life styles of their staff.³

This marriage, however, not at all well established, has a clouded past. "Far from being a natural match," observes Joseph Ben-David, "research and teaching can be organized within a single framework only under specific circumstances.⁴ Historically, this unification of science and the university found its best example in Germany, specifically in the University of Berlin in the nineteenth century today, is best represented by the leading universities in the United States.

The vitality of these systems of higher education made them models to be followed and imitated internationally; and the notion that the universities are the natural setting for research follows naturally. The reverse, however, is not nearly so clear. The volume that brings together the classic papers of Robert K. Merton on the sociology of science contains references to universities on only seven of its 600 pages.⁵ A more recent book, *Science, Technology and Society*, does not fare much better: it has about twenty scattered references to universities within its 600 pages. None of these references make any mention of systems of higher education in a broader sense.⁶

³ Halsey, "Changing Functions of Universities", pp. 460-463.

⁴ Ben-David, *Centers of Learning*, p. 94.

⁵ Merton, *Sociology of Science*.

⁶ Spiegel-Rösing and Price, eds., *Science, Technology and Society*.

If the marriage has so many problems, why insist on it? It would be very easy to show that the overlap between the systems of science production and those of higher education has not been significant in the past and to muster good reasons for keeping them apart in the future. There is, however, an obvious gap between this empirical reality and the strong convictions about the linkages between science and higher education; this fact is significant in itself and should be examined with care. Let us first examine the evidence, and then try to understand the tensions and difficulties that are involved.

Science and Higher Education: Past and Present

With reference to the past, let it be understood that we are not dealing here with two well-identified social realities, but rather with several highly changing aspects of social phenomena which often come together under the same names.⁷ "Higher education" in contemporary¹ systems, bringing together thousands of teachers and millions of students, is very different from the type of advanced learning which took place in the old and exclusive European universities of past centuries. Aside from the obvious differences in structure and size, the systems of higher education have traditionally performed (and still do) at least three quite different but not necessarily convergent functions. First, there was the national role of training for the scholarly professions, law, medicine, and theology. This function was later expanded to include the new technology-oriented engineering careers. Second, the function of general education, first serving as propaedeutics for the professions, gradually evolved as a cultural and intellectual function on its own. Third, the function of generating new knowledge is, in modern times, associated with the idea of "science."

"Science" has different meanings, and sociologists of science often give to it a narrow definition which makes it only one among several forms of advanced knowledge. In this specific sense, scientific knowledge is based on empirical observation, in contrast with classical knowledge based on hermeneutics and rational speculation; it tends to be systematized and geared toward explanation, in contrast with practical, applied

⁷ This stability of names for changing realities is central to Harold Perkin's analysis of higher education as a historical system (see chap. 1, above). See also his overview of the development of modern universities from its medieval origins and the impact of the nineteenth-century German model in other countries.

knowledge; it is produced by a community of freethinking scholars, in opposition to all forms of authoritative systems of thought and belief.

Science as technological knowledge is very old, and all forms of higher education have always implied, if not the production, at least the systematization and transmission of highly developed knowledge.⁸ Historians of science narrowly tend to link its emergence to the European Renaissance, as part of the general breakdown of medieval order and the assertion of individualism in its different cultural, intellectual, and economic forms. The institutional history⁹ of European science up to the beginning of the nineteenth century is a tale of its gradual conquest of a central position in the culture and international outlook of Western societies. Experimental science, as it is also called, evolved basically outside and in opposition to the traditional universities. Only in the nineteenth century did they establish the intimacy that today is often taken for granted.⁹

The starting point of this long process is probably best dramatized by Galileo Galilei's plight, but less because of his specific proposition that the earth revolves around the sun than because of the way the truth is to be established, be it through the authority of "classical" works endorsed by the Church or through empirical observations and rational persuasion.¹⁰ Galileo's prosecution was one of the last attempts of the religious establishment of his time to keep the findings of empirical observation of the physical world subordinated to its dogmas and institutional authority. From that time on, and in line with the individualist ethics of emerging capitalism and Protestantism, empirical science has flourished, moving from its main cradle, Italy, to the much more fertile soils of France, England, and, later, Germany. In the nineteenth century, with Darwin's evolutionism, the biological sciences took their turn in establishing their autonomy while confronting the religious dogmas of the time.

⁸ About non-Western forms of scientific knowledge in a broader sense, see Needham, *The Grand Titration*

⁹ For this history see Ben-David, *Scientist's Role in Society*.

¹⁰ . Galileo's telescope "did not prove the validity of Copernicus' conceptual system. But it did provide an immensely effective weapon for the battle. It was not proof, but it was propaganda. " After Galileo's observations Copernicanism could not be dismissed as a mere mathematical device, useful but without physical support." This explains in part the strong opposition it aroused (See Kuhn, *Copernican Revolution.*) I am grateful to Sheldon Rothblatt for calling my attention to this point.)

This new and increasingly prestigious type of knowledge did not easily become a part of the university. The universities in Paris, Oxford, and Cambridge were older centers of classical learning and as such paid no more than secondary attention to the empirical sciences. In England, however, scientists of the new type met at the Royal Society, founded in 1660. Its aim, according to its founders, was eminently practical and technical:" (. . .) to improve the knowledge of natural things, and all useful Arts, Manufactures, Mechanick practices, Engynes, and Inventions by Experiments (not meddling with Divinity, Morals, Politicks, Rhetoric or Logick).¹¹

This definition of purposes did not correspond to the full truth, since many of the leading figures of the Royal Society (Robert Boyle, John Wilkins, and several other members of the "Philosophical College" that gave birth to the Royal Society) were strongly identified with Puritanism and parliamentarianism. The practical purposes of the society tended to make room for a much more ambitious view of the new science, as the foundation of a new philosophy. If in its first years the practical influence of Francis Bacon was very strong; it "declined during the 1670's and. was supplanted by a 'Galileian' trend as manifest above all in the work of Newton who became a fellow of the Society in 1671.¹²

A similar practical aim preceded the establishment of the French Academy of Sciences in 1666. Contrary to its English counterpart, it was not a voluntary association, but a government-sponsored institution organized with the explicit aim of helping the expansion of French commerce and industry. Nevertheless, the scientific success of the French Academy seems to have been inversely proportional to its devotion to practical tasks.

In both England and France the establishment of scientific societies played a dual role. On the one hand, practical and useful purposes were served which benefitted only the economic and political elites of that time. On the other, groups of distinguished scientists launched a protracted assault on the traditional culture and philosophy, whose strongholds were the traditional universities. This new science was, in other words, the foundation of a new world vision - some authors have called it a "scientistic ideology" -

¹¹ Quoted by Mason, *History of the Sciences*, p. 259.

¹² . Ibid, p. 260.

linked to the emergence of new social groups who benefitted from the social, political, and economic changes brought about by the industrial revolution they engendered. The climax of this process was the publication of Isaac Newton's *Philosophiae Naturalis Principia Mathematica*, the mathematical foundation of natural philosophy. The title was a clear indication of the immensity of Newton's undertaking, which went far beyond a simple and utilitarian determination of empirical phenomena. What Newton achieved was a new understanding of the universe, where reason combined gracefully with empirical observation. Modern science, with the Newtonian synthesis, finally reached its dominant position in relation to the old scholastic culture, by means of its own language and style. There was an obvious analogy¹³ between the harmony of Newton's universe and the ideal of social harmony which was to be created by the advance of individual freedom and rationality.¹³

While Newton provided the empirical sciences with the necessary respectability to challenge the old scholarship entrenched in the universities, the modernization of the professions gradually forced open other gates. In the eighteenth century some institutions began to provide a much more technical and specialized type of education than that found in traditional universities-medicine in the Scottish universities and engineering in the École Normale des Ponts et Chaussés in France and in the Gergakademie in Freiberg were among the best known. Very often the new professional training was provided outside the university, and the tendency around 1800 seemed to suggest that education for the "learned professions" provided by the traditional universities was about to disappear, taking with it the whole system of professional privileges it entailed".¹⁴ The new trend was related to two pressures: the need to bring to the old professions the new knowledge being produced by the experimental sciences; and the need to break the privileges of the old professions and their corporations so as to allow for the emergence of new professions, new schools, new methods of teaching and learning, and the final substitution of one intellectual elite for another. In no country was this substitution more dramatic than in France. According to Ben-David,

¹³ See Crosland, ed., *Emergence of Science in Western Europe*; Merton, *Science, Technology and Society in Seventeenth Century England*; Bernal, *Science in History*.

¹⁴ Ben-David, *Centers of Learning*, p. 36.

The new system that began to emerge in 1794 consisted of a series of professional schools for teachers doctors, and engineers needed by the state. Scientific studies and scientific philosophy were to inherit the central place that had been occupied by the classics in both secondary and higher education. Eventually, under Napoleon, the scientific orientation was weakened, the emphasis on the new scientific philosophy was completely abolished, and classical learning was restored to its former importance in secondary schooling. But higher education remained identified with specialized education for various professions.¹⁵

Gradually the old privileges were replaced by new ones. The Grandes Écoles created by the Napoleonic system to form the technical cadres for the state became centers for training the new French intellectual leadership. While these schools provided a high-level education for the elite, a second tier of higher education was created for the larger population, eventually incorporating some of the institutional elements of the old universities. The Grandes Écoles performed, in practice, a subversion of the old notion that general education should precede and provide the foundation for professional training. In the new system, specialized education was perceived as the best way to intellectual development, and those who passed through these schools were considered men of a new type of culture.¹⁶ Scientific research was never a central activity in this system; it was tangentially taught by some scientists, who did most of their work in separate institutions.

Changes in Britain were more complex and less dramatic. The old, traditional universities never abandoned their role of training the country's aristocracy, but they gradually included in their programs the specialized studies of modern science, while insisting, according to Ben-David, that "the purpose of specialized study was not necessarily the acquisition of practical skills, but that it was the best way to the education of the mind and was an end in itself."¹⁷ At the same time other institutions of higher learning, more directly geared toward professional education, started to appear. Ultimately, professional training became the main aim of the country's higher education system, but the emphasis

¹⁵ Ibid., pp.15-16.

¹⁶ Gilpin, *France in the Age of the Scientific State*.

¹⁷ Ben-David, *Centers of Learning*, p. 75.

on scholarship and general education provided fertile ground for scientific research in the leading universities.

The most widespread revolution, which would become the model for other countries in the late nineteenth century, was the one that began at the University of Berlin. The more general social context seems to have been provided by the emergence of an educated middle class which lacked the alternatives of economic and social participation existing in England and France at the time, and which placed all the pressures for mobility; on the state and on the educational system. The university became one of the few channels of social mobility available to this emerging group, and its social role was perceived as much more than a simple ground for professional training. The philosophical meaning of the new knowledge developed at German universities tended to be emphasized by the preeminence given to the German philosophers (beginning with Kant, who sought to provide the philosophical foundation for modern science) and by the development of Naturphilosophie, a much more humanistic and romantic vision of the world than the Cartesianism and positivism that had spread to the rest of Europe from France. The strength and vitality of the German scientific community is expressed by the establishment, in 1822, of the Deutsche Natufforscher Versammlung, an association of German-speaking scientists and doctors which preceded the political unification of Germany by several decades.¹⁸

It was in this context that an effective integration between teaching and research was achieved for the first time. It occurred early in the fields of chemistry, pharmacy, and physiology, disciplines that were systematized enough to allow for coherent and integrated teaching with an experimental content. More important than the content, however, was the fact that a large educational system was being created in German-speaking countries and scientific production became a decisive factor in the competition for prestigious positions in that system. The universities, to enhance their reputation, searched for researchers, while they, in turn, demanded laboratories and other research facilities. Students who wished to enter university careers were obliged to follow the path of their masters, and physicians, chemists, and pharmacists had the opportunity to obtain

¹⁸ Mason, History of the Sciences, pp.578 ff.

scientific training in their schools. From the beginning this university system benefitted from the strong ties it established with the emerging German chemical and pharmaceutical industries.

The notion that teaching and research should necessarily be joined arose from this context and became the model in spite of obvious difficulties.¹⁹ Scientific research tends to absorb resources and time, which is often a liability and a problem for institutions geared to professional training. Also, the qualifications needed for a scientific education are often superior and much more specialized than those required for the competent exercise of the professions. These difficulties have been overcome in some places and times; in Germany they led to the creation of a differentiated system of scientific research, the Kaiser Wilhelm Gesellschaft (today the Max-Planck Institutes). The American system, when it later revived the linkage between teaching and research, did so through an absolute innovation: the establishment of scientific careers in graduate schools side by side with education for the classic professions. A doctoral degree in this new system became an alternative to a professional title. In the European system, in contrast, the degree is mostly a preparation for advancement in a teaching career within the university. In other words, scientific research in the American model is not a propaedeutic activity in the teaching process but a goal of its own, with its own requirements, resources, and dedication. This system, though not enough to bring all research into the universities, provided science with much more room than it ever had in other countries and places.

This historical overview confirms the lopsidedness of the relationship between science and higher education. From the standpoint of science, systems of higher education are not necessarily very important. For those who think of science in Mertonian terms - as the work of a community of scholars engaged in the search for truth - what is paramount is the absence of social and political pressures that might challenge the scientist's commitment to the norms of the scientific ethos. The university can provide a favorable environment for scientists, but it can also threaten them with the imposition of external

¹⁹ It has been noted that the German *Wissenschaft* is much broader than the English "science", since it includes a component of scholarship which is not necessarily part of its Anglo-Saxon meaning. Cf. Mayr, "Science-Technology Relationship."

criteria and demands on their work.²⁰ For those who think of science and technology as an integrated component of modern industrial societies, the emphasis is much more on the linkages between science and economy than on those between science and the educational system.²¹ With this perspective, as exemplified by Halsey's comment at the beginning of this chapter, university research is nothing but one sector of a large research and development establishment, and the educational process is identical with manpower training.

The picture is not the same from the point of view of the higher education system. Here, the notion that the university is basically a community of scholars engaged in the pursuit of knowledge plays a highly significant role in the legitimization of its demands for social recognition, autonomy, resources, and prestige. This role is no doubt more strongly stressed in countries where other functions of higher education - professional training, general education-are still not well established. It is certainly not by chance that, in a country such as Brazil, the expressions "higher education system" and "university" are used almost interchangeably, so that the aura of prestige usually associated with the latter is extended to the former. This legitimization function explains, according to Joseph Ben-David, the resistance of most university systems to accepting the differentiation of their functions. For Ben-David, "this combination of advanced research and study has been realized only in small parts of the university, but those parts, in which teachers and students use their freedom for its original purpose of research and study, have legitimated the turning of freedom by others who do not do research or study into unjustified privilege."²²

²⁰ See Merton, "Science and the Social Order," in *Sociology of Science*, p.256, for the plight of scientific research in German universities during the Nazi regime.

²¹ For an overview, see Böhme, "Models for the Development of Science," pp.319-354

²² Ben-David, *Centers of Learning*, p.166. A recent publication from the Organization for Economic Cooperation and Development lists four arguments against the differentiation of careers for researchers and teachers in the universities of the OECD countries. They are, first, the creation of a stratification between them with first- and second-class citizens; second, the loss of quality of teaching; third, the creation of an institutional split between teaching and research institutions; and fourth, the instability of the research institutions themselves because of their dependency on the countries' R&D changing budgets and policies. While acknowledging all the difficulties of the relationships between research and teaching at the universities, the OECD concludes that new organizational forms should be tried to reestablish the old belief in the indivisibility between them. (OECD, *L'Avenir de la Recherche Universitaire*, pp. 49-50, 86.)

Systems of higher education in general, then, need science more than the scientific systems need them. For this reason the notion that science finds its "natural" place in the university seems to be self-evident (when seen from the latter's standpoint) and is so even in societies where linkages between the two are rather weak. If this is true, one might expect that systems of higher education would commonly reserve a special place for scientific research. In fact, they very often do, but the coexistence of scientific research with other explicit and implicit functions of the educational systems is not always pacific.

In short, the study of higher education systems from the perspective of their relationships with scientific research calls attention to some paradoxes that, if properly understood, lead to a better understanding of the systems' mechanisms of social legitimization. The basic paradox is that there is a large gap between the ideology of the centrality of scientific research in the higher educational systems and the historical fact that the overlap between the two is problematical and often reduced to a small number of elite universities. If the empirical and historical analysis is not done properly, there is the danger of taking ideology' for reality and of overlooking the other functions performed by systems of higher education as well as the different institutional settings where scientific research tends to base itself. When properly understood, however, the analysis illuminates some basic inner tensions and conflicts frequently observed in higher education systems which are often ignored when they are seen only from a strictly educational or functional point of view.

Science in Latin America

Latin America is a living laboratory, a privileged ground in which to examine the interplay among scientific research, scientific ideologies, and the realities of higher education systems. The Latin American educational institutions have always been part of Western culture, but they very often are superimposed upon a completely different society. This duality sometimes has been interpreted as a contradiction between the "ideal" and the "real" Latin American societies, leading to the notion that the "ideal," or "European," parts are false and alienated and should be replaced by the "real" ones. In fact, this contradiction is part of the reality itself, and this is probably one of the reasons why ideologies play so important a role in these societies. Science, as the ideal of

Western rationality, is an obvious candidate for ideologies that affect educational systems most directly²³.

The Iberic Heritage

Spain, from the early sixteenth century, brought its university system to Latin America, but Portugal did not.²⁴ At the time of independence, in the early nineteenth century, there were universities in Mexico, Peru, Cuba, Guatemala, Chile, and Argentina, among other countries. In Brazil, under Portuguese influence, the first schools of higher education were established no earlier than 1808, and only in 1920 was the first university created in Rio de Janeiro. The ties with Spain were severed during the wars of independence, and the old, church-controlled universities were transformed according to the French Napoleonic professional model: different schools, or "faculties," for each profession, and official licenses for professional practice granted by the government to students upon graduation. In Brazil, where there was more continuity with Portugal, a few technical schools and institutions were established by an exiled Portuguese king in the first decades of the nineteenth century: a botanic garden, a library, a naval and military school, two schools of medicine, two schools of law, a museum of natural history.²⁵ Eventually, the Brazilian system also developed in the direction of the Napoleonic model, and the universities and professional schools became a necessary step for access to bureaucratic and political positions by the children of the elites.

Without trying to cover the wide variety of experiences throughout the continent, it is safe to say that the professional schools did not emphasize technical training and, even less, scientific research. Medicine and engineering are supposedly technical professions and, therefore, should command some measure of technical expertise. But the

²³ For an earlier version of the problems discussed in the following section. see Silvert, ed., *Social Reality of Scientific Myth*.

²⁴ The following analysis is based in part on Schwartzman "Universidade, Ciência e Subdesenvolvimento," which is published also in Lavados Montes, ed. " Universidad Contemporanea, pp. 57-78.

²⁵ For the contrast between Portuguese and Spanish educational practices in their colonies, see Carvalho, "Political Elites and State Building." For a detailed history of Brazilian developments in science and professional education, see Schwartzman, *Formação da Comunidade Científica no Brasil*. For specific information on different scientific traditions, see Azevedo, ed., *As Ciências no Brasil*. For an overview of Argentina's experience, see Babini, *La Evolución del Pensamiento Científico en la Argentina* and *Las Ciencias en Argentina*.

requirements for professional licensing tended to be formal and bureaucratic, rather than substantive and technical, and the professional schools tended, as a rule, to expel or push to the margin those who tried to bring them closer to the European standards of proficiency.

Scientific research was typically brought to Latin American countries in the late nineteenth and early twentieth centuries by foreign immigrants who worked in government research institutions outside the university systems: astronomic observatories, geographic and geologic institutes, botanic gardens, museums of natural history, and, later, institutions for public health and disease control. There, the newcomers eventually trained their own disciples and sometimes taught at the engineering and medical schools and at the universities. They usually tried to expand research beyond their institutional charters, and sometimes they were successful, as in the case of the Manguinhos Institute of Bacteriology in Rio de Janeiro.²⁶ In general, however, they could not expand or institutionalize their work as part of a long-lasting scientific tradition; the impact of their work, if it was transmitted, was mainly perceived in Europe.

By the time of World War II research in science had already made significant inroads in the university systems of some of the largest Latin American countries, and the notion that these universities could become the preferred place for the scientific development of these countries did make some sense. A few centers of medical and biological research attained high standards of scientific work, among them the Instituto de Fisiología of the Universidad de Buenos Aires, under Bernardo A. Houssay (Nobel prize in physiology and medicine, 1947), and later the Instituto de Biofísica of the Universidade do Rio de Janeiro, under Carlos Chagas Filho.

Advances in medical and biological research tended to have a limited impact on the higher education system as a whole, as they were largely restricted to the medical schools and related institutes. The introduction of modern mathematics and physics, on the other hand, was usually coupled with projects for comprehensive reforms of the universities and of the educational system in general. These projects were often inspired by some version of the nineteenth-century German model of integration of science and teaching,

²⁶ Stepan, *Beginning of Brazilian Science*; Fonseca Filho, "A Escola de Manguinhos."

even when the most apparent influence was French, as in the case of the Brazilian initiatives in the 1930s. (The old Escola de Medicina, however, incorporated in the Universidade de São Paulo in 1934, was already receiving support from the Rockefeller Foundation and established full-time teaching and research in the decade 1910- 1920.²⁷

The Introduction of Science and the Search for a New University

The most comprehensive attempt to launch science within a new university in Brazil was the establishment of the Universidade de São Paulo and its Faculdade de Filosofia, Ciências e Letras in 1934. This university was created during a period of intense mobilization by the state of São Paulo's economic and intellectual elite in the wake of their defeat in the conflict with the Vargas regime. The state of São Paulo was already the country's economic leader, thanks to the coffee plantations and to an emerging industrial complex that had started to grow in association with it, benefitting from a large mass of European immigrants. A new university, structured around a school of sciences, was thought to be a long-range project that could give the state the leadership position its elite desired. At the same time it could provide the state with the intellectual, technical, and professional cadres needed in a rapidly modernizing economy. All members of the new Faculdade were recruited in Europe. German chemists and biologists, Italian physicists and mathematicians, French historians and anthropologists, all came with different motivations and for different periods. Some remained throughout the years of World War II and afterward.

Thanks to the quality of some of the new professors and students, to the autonomy granted the university in its first years (which contrasted sharply with the growing centralization that was the landmark of the Vargas regime), and to the resources that a growing state economy provided, the Universidade de São Paulo became the most important teaching and research establishment in the country. As a center for scientific and technological research, however, it was limited by the initial constraints of the Faculdade de Filosofia as well as by established interests in professional careers.

²⁷ See Schwartzman, *Formação da Comunidade Científica no Brasil*, chapter 7, for the creation of the University of São Paulo), and chap. 8, pp. 242-249, for the presence of the Rockefeller Foundation in Brazil. For an overview, see Schwartzman, "Struggling to Be Born", pp. 545-580.

A similar, if less successful, attempt was made a few years later in Rio de Janeiro by Brazil's Ministry of Education. In 1937 most of the city's higher education institutions were brought together under a newly created Universidade do Brasil, which was supposed to be the model for all institutions of higher education in the country. According to its plan (which became law in 1937), the university had to establish courses and research facilities in all areas, and a new Faculdade de Filosofia, Ciências e Letras was to be created, also staffed with foreign scholars. This project was less successful than the earlier one in São Paulo for several reasons, one of which was the authoritarian climate that prevailed in the Brazilian national government from 1937 to 1945. The new school never attained São Paulo's quality, and it had little influence over the older parts of the university. The notion that a single model could be established for the whole country, however, together with the idea that all higher education should be buttressed by scientific research, became an undisputed assumption for Brazil's education policy in the years that followed.²⁸

Postwar Optimism: University Science and Technology Development

Optimism was high in the first years after World War II regarding the positive role science and technology might play in raising the levels of social and economic development in Latin American countries. The war, having shown the awesome destructive power of science and technology, led to the hope that if oriented constructively these forces would have a positive impact upon society. The wave of technological change which swept the industrial and agricultural sectors in those years seemed only to confirm this idea.²⁹

In Chile, the formation of the National Council for Scientific and Technological Research was suggested in the early 1950s by the dean of the Facultad de Ciencias Fisicas y

²⁸ See Schwartzman, "A Universidade Padrão."

²⁹ The idea that scientific research should be brought to bear upon a central role in national planning was first put forward by the Soviet Union, was adopted by the French in the years of the Front Populaire (which led to the creation of the Centre Nationale de la Recherche Scientifique), and was supported very strongly in England by the group of Marxist scientists led by J. D. Bernal. In the United States it was adopted during World War II by the Organization for Scientific Research and Development which, under Vannevar Bush, had direct access to President Franklin Roosevelt. See, among others, Graham, "Formation of Soviet Research Institutes"; Bernal, *Social Function of Science*, Gilpin, *France in the Age of the Scientific State*; McGucken, "Scientific and Technological Advice in the United Kingdom during the Second World War."

Matemáticas of the Universidad de Chile. He believed research, government, teaching, and economic development in Chile, and in South America in general, should be joined:

Development agencies, linked closely with the universities, must necessarily influence the orientation and priority given to large-scale national-level research in areas relating to these countries' natural resources and their improved exploitation. We also believe that technological research should be closely related to high-level scientific training, and through this medium to scientific research and teaching”³⁰.

This idea was implemented with relative success during the tenure of Juan Gómez Millas as rector of the Universidad de Chile (1953-1958). A law in 1954 created the Fund for University Construction and Research, which specified that plants, laboratories, experimental stations, and research institutes be created and oriented "toward cooperation with the Corporation for the Development of Production, with state technical organs, and with private entities and firms. A council, made up of the Rectors of all the universities in the country, headed by the Rector of the Universidad de Chile, was to prepare annual plans for coordinating all the technological research which the universities carried out.”³¹

The view that science at the universities could play a central role in socioeconomic development was part of a "developmentalist" ideology that emanated from the United Nations' Economic Commission for Latin America (ECLAC). In a document published in 1970, Raúl Prebisch emphasized the need for the adaptation and recombination of international technological knowledge to meet the specific conditions of Latin America. He pointed out that priorities should be established from an economic planning point of view, and that research programs should be organized to respond to these priorities. "All this has a close relationship with education. It will be necessary to promote educational programs that, besides the diffusion of technologies, should have as one of their main purposes, the stimulation of the creative capacity in this field."³²

³⁰ Quoted by Fuenzalida, "Institutionalization of Research," p. 12. The following presentation of the Chilean experience is based on Fuenzalida's paper.

³¹ Ibid, n 19.

³² Prebisch, Transformación y Desarrollo, quoted by Graciarena, Formación de postgrado en ciencias sociales en América Latina, p. 32. For an overall view of Prebisch's role and ideas, see Love, Centro-Periferia e Troca Desigual." See also Balán, "Social Sciences in the Periphery."

While agreeing with Prebisch that the educational system could do little by itself without an overall policy of socioeconomic development, Jorge Graciarena, a sociologist who also belonged to ECLAC, believed that "until now, the Latin American university has remained at the margin of the problems of underdevelopment because of its little or no capacity to identify and solve them... Today, however, it is difficult to conceive future solutions for the basic problems of development without a more active and large participation of the university," which had two strategic roles to play: to train manpower and to produce knowledge - not any knowledge, however, but knowledge that would be relevant to local conditions. Thus there was need for a "national, scientific ideology" and even a Latin American ideology, which in fact was present in the frustrated attempt to organize a continent-wide system of graduate courses in the social sciences.³³

This idea also found support in the United States and was a significant part of the Alliance for Progress program during John Kennedy's tenure, both directly through the United States Agency for International Development and indirectly via several private foundations which increased their activities in South America during the 1960s. Chile was a privileged recipient of this type of international support. In 1965, after a long internal discussion, the Facultad de Ciencias was established at the Universidad de Chile. Its creation coincided with an ambitious *convenio* between the University of Chile and the University of California, with support from the Ford Foundation; the agreement specified reciprocal acknowledgment of courses of study and degrees between the two institutions and several cooperative programs. During the 1965-1978 period, 323 Chileans and 287 Californians took part in the program: "127 Chileans obtained degrees from the University of California; 42 in Agriculture and Veterinary Medicine; 4 in Arts and Literature; 6 in the Library Development Program; 63 in Natural Sciences and Engineering; 12 in Social Science. Close to 1,000 books, articles in journals, papers presented to conferences and meetings, dissertations, theses, audio recordings, films,

³³ Graciarena, *Formación de postgrado en ciencias sociales en América Latina*, pp.33-34 (my translation). This project was nursed for several years by the Latin American Council of Social Sciences, and had it succeeded, it could have counted on the support of the United Nations Development Program.

paintings, resulted from research projects supported directly or indirectly by Convenio funds during the period 1964-78.³⁴

A similar, optimistic view preceded the creation of the Universidade de Brasilia in the early 1960s under the inspiration of Darcy Ribeiro. For him, "the mastery and cultivation of science - as the language of the emerging civilization - can be fruitfully achieved only within the universities, specially in underdeveloped countries. Isolated institutes tend to become wasteful institutions of low scientific creativity, with almost no contribution in terms of technological research and nothing whatsoever regarding the education of highly qualified personnel. The university, on the contrary, as it performs its role as a teaching institution at the graduate level, can and must not only contribute to the understanding of man and nature but must also develop, as a by-product of its day-to-day activities, the multipliers of research that could lead to the development of science, self-awareness of the national reality, and the search for solutions of its problems.³⁵ This was not to be a university simply for professors and scientists; it was to be for intellectuals, "each of whom would project his own field through a personal and sometimes dramatic experience of the Brazilian reality. That is, each one, instead of alienating himself, had to confront the Brazilian problem with his whole body and soul, on questions not only about the university but also about its social, political and economic aspects. Although not all of them had the same level of experience, they all knew the derogatory meaning that used to be attached in Brazil to the label 'intellectual,' and they did not hide their disposition to change it through the active transformation of our social and political process.³⁶

The modernization of the Facultad de Ciencias Exactas y Naturales of the Universidad de Buenos Aires, after the end of the first Peronist period in 1955, followed a similar inspiration. In 1966 its director, Rolando V. Garcia, presented a paper to the Fifth Pugwash Conference containing one of the stronger and more explicit endorsements of the notion that science should develop through the universities. Comparing Latin American with northern universities, Garcia said that "Latin American universities are

³⁴ Fuenzalida, "Institutionalization of Research," pp.51-52.

³⁵ Ribeiro, *A Universidade Necessária*, p. 245 (my translation).

³⁶ Heron de Alencar, "A Universidade de Brasilia," p.272 (my translation).

much more complex living organisms. They are, on many occasions, the vanguard of the most progressive forces in the country. Historically, they have always taken an active part in every important political or social struggle. No wonder that most governments, the armed forces, and the Church are afraid of the universities.³⁷ The political turbulence of the Latin American universities contrasted with the serenity of Harvard, Oxford, or the Sorbonne, "quiet places where students are given regular doses of academic wisdom and provided with a detached attitude toward those problems which are the concern of professional politicians."³⁸ This turbulence was a good thing, according to Garcia, and implied a continuing two-front struggle. One side of the conflict was political, external to the university, and was to change the social, economic, and political conditions that were responsible for underdevelopment. The other was internal, a conflict against the "sacred cows" who did not allow for the development of institutions that could be fully aware of their responsibilities. The internal task was, essentially, "the process of transforming an institution dominated by lawyers and physicians into an institution where physicists, mathematicians, chemists and biologists share with specialists in social science and public health the highest priority." This transformed university should work according to a global plan that should be established as "a body at the highest governmental level where economists, scientists and technical officers of all (technical) branches of government meet to consult and to lay down the scientific policy of the country'. The participation of the universities is here of primary importance."

The Modern Crisis

It is obvious that these different projects included individuals with different ideologies and visions of the role science, higher education, and the universities should play in the transformation of their societies. More seriously, experience has shown that it was relatively easy to improve the quality of small graduate programs, much more difficult to change the higher educational systems as a whole, and almost impossible to make

³⁷ Garcia, "Organizing Scientific Research," p.12. For a historical view of the Universidad de Buenos Aires and its sociopolitical context up to this period, see Halperin Donghi, *Historia de la Universidad de Buenos Aires*.

³⁸ On student political activism, see Albornoz, *Ideología y Política*; Altbach, "The International Student Movement"; Lipset, *Student Politics*.

significant improvements beyond that. Besides, the expansion and modernization of the economy in the region after the war were based in large part on the introduction of foreign capital and ready-made technology from outside, with little demand for local advanced research and highly trained manpower. In fact, the changes required the services of only a limited portion of the region's population, leading to increased differentiation between its "modern" and "traditional" sectors. Chile and Argentina, which already had a sizable and modernized middle sector from prewar days, witnessed a process of slow educational obsolescence and professional downgrading of large sections of their urban and educated populations; this led to potentially explosive cleavages between the latter and the smaller sectors that followed more closely the postwar pace of change. In the first few years it was probably hard to foresee the difficulty of bringing native technological and scientific resources to bear on the industrialization and modernization process through higher education. As time passed, however, an ideological cleavage emerged between those who believed that science, technological research, and education should play a central role in the creation of a new, autonomous, and more egalitarian society and those who accepted the realities of a limited, dualistic, less autonomous, and dependent model. This cleavage eventually led to left-right, or liberal-conservative, confrontations.

Scientific research in and institutional modernization of the Latin American universities benefitted extensively from North American influence or support, ranging from the Ford Foundation grant to the Chilean *Convenio* to large fellowship programs given to Latin American scientists by the United States Agency for International Development and by the Ford, Rockefeller, and other foundations. North American influence on the organizational model of the new Universidade de Brasilia was obvious. The American support, however, did not preclude the nationalist and often anti-American perspective of many of those engaged in these projects, for the United States was perceived as the main source of the region's foreign dependency and internal balkanization and dualism. As political life became more polarized in the late 1960s, ideology increased its weight. This contradictory situation was expressed very clearly by Felipe Herrera Lane, a Chilean who was for many years president of the Interamerican Development Bank, which played an important role in the financing of educational projects throughout Latin America. "In

several countries there were those who considered . . . [the bank] to be a mere agent of the United States attempting to gain control of the higher education systems in Latin America, in spite of a Latin American 'image' we tried to develop with much sacrifice. I remember that, in my constant travels through the continent, one of the most stimulating challenges was the dialogue with the academic communities, explaining to them how Latin America was the true inspiration of the bank, and that the resources at the universities' disposal were meant to make them effective instruments in a task that included not only our economic independence, but also the affirmation of our traditions and cultural values.³⁹

Crisis struck at these optimistic experiences with differing degrees of intensity and violence during the sixties. The intellectuals responsible for the organization of the Universidade de Brasilia entered into confrontation against the military regime that took power in 1964 and were forced to resign. Several of the organizational innovations of the Universidade de Brasilia, however, were later adopted in a nationwide university reform movement which introduced the departmental structure, set up the credit system for courses, and abolished the system of "chaired" professorships in Brazil. The following years saw sweeping changes in Brazil's higher education system, not only because of the reform, but mainly as a result of an extremely rapid increase in enrollments, which went from 142,000 in 1964 to 900,000 ten years later, and then to about 1.5 million in 1980. This expansion was followed by the creation of a huge system of graduate education: with only six graduate programs in the country before 1960, 123 were created between 1960 and 1970 and 620 in the ensuing decade.⁴⁰ The establishment of graduate schools, however, coincided with political mobilization and repression at the universities, which culminated in extensive student mobilization in 1968 and in the forced retirement, in the next two years, of dozens of the most talented professors and scientists at the country's leading universities and research centers.

³⁹ Herera Lane, "Dinámica Social y Desafíos Educacionales," p.30 (my translation).

⁴⁰ Unpublished data from the Brazilian Ministry of Education. CAPES, 1982. For data on Brazilian graduate programs after 1975, see "Pósgraduação no Brasil." For a discussion of the crisis in the undergraduate system, see Schwartzman, "A Crise da Universidade." pp. 96-126.

Argentina was next. In 1966, the year in which the military government took power, it intervened in the Universidad de Buenos Aires with a violent invasion of the Facultad de Ciencias Exactas y Naturales. As a consequence, thousands of professors in all departments of the university - but mostly in the physical and social sciences - resigned.

This occurrence is still hotly discussed in Latin America: some believe that the university suffered because it was involved heavily in politics; others think exactly the opposite. Looking back at these events from the perspective of 1980, one of the major participants, Professor Manuel Sadosky, concluded that "our main weakness was that we did not do enough politically, in the best sense of the word, to convince the students that they were making a commitment to the country which they had to fulfill by placing their knowledge to work for the socioeconomic change that was indispensable for breaking the structures of the status quo." He partly accepts the charge of "scientificist" when he says that "we raised the requirements for study and work so much that, unwillingly, we contributed to the isolation of the students from political life. " He believes, however, that it was the consciousness-raising activities that finally brought on the wrath of the conservative sectors in his own country and also in the United States: "Not only the local reactionaries considered us their enemies; in the North American Congress itself some representatives expressed their concern for the impetus that some of the more progressive universities in Latin America were getting. It is certainly not a coincidence that the most brilliant achievements of the universities of Buenos Aires, Brasilia, Montevideo, and, later, Santiago de Chile were annihilated with similar methods and harshness.⁴¹

In Chile, the crisis was slower to come. The implementation of the *Convenio* with the University of California slowed down after the university reform in the last few years of Eduardo Frei's government, and activities were kept limited during the Salvador Allende years. After the intervention in Chilean universities which followed the 1973 military

⁴¹ . Sadosky, "Una Experiencia Educativa Argentina," p.108 (my translation). A similar view was expressed by another eyewitness of the events, Amilcar O. Herrera: "If any doubt remained that these were not mere irreflective acts, simple consequences of momentary political passions, it can be dispelled by pointing out that all subsequent acts show the intention of keeping these scientific centers (Facultad de Ciências Exactas of the Universidad of Buenos Aires and the Universidade de Brasilia) in the deplorable state they were in after the interventions" (Herrera, *Ciencia Politica en America Latina*, p.40; my translation). The fact is, however, that the Universidade de Brasilia was not destroyed in spite of its successive crises, and today it is well above average among Brazilian higher education institutions.

coup, the Ford Foundation's remaining resources were restricted to helping only Chilean students who were already at the University of California.⁴²

The *Convenio* showed, in 1978, mixed academic results, with better scientific performance in the fields of agriculture, veterinary medicine, and the hard sciences than in the social sciences. But the links established by the program became a liability when funds started to dry up. "Not only current activities are affected. Since libraries are forced to cancel subscriptions to journals, and equipment cannot be repaired or replaced with up-to-date ones, new research projects cannot be developed by the Chileans. The researchers themselves, frustrated by their working conditions, which they find particularly unbearable because of their firsthand and detailed knowledge of the working conditions of their Californian counterpart, end up leaving the University, or the country altogether."⁴³ After so much effort and hope the final balance was rather dismaying: "Whatever the *Convenio* is able to create in the University of Chile in the area of science and technology lacks roots in the Chilean soil. If foreign support does not come to the rescue (in the form of grants of foundations other than from Ford) these activities are bound to disappear." "The new University of Chile that resulted is unable to keep its programs working in these areas (veterinary medicine, basic science, and engineering) without a constant flow of resources, people, and ideas from the center. Instead of producing a modern higher education institution capable of self-sustained growth, the *Convenio* contributed to the creation of a subsidiary of the international centers of higher education (particularly the University of California)."⁴⁴

Out of the Ashes?

It is difficult to evaluate the impact of the crisis in the different higher education systems throughout the continent. Most of the confrontation and repression that occurred in these years had little to do with scientific research at the universities, but a great deal more with the radicalization that swept the continent when the expectation of social, political, and

⁴² "Institutionalization of Research," p.74, n. 6.

⁴³ Ibid, p. 56.

⁴⁴ Ibid, p. 57.

economic participation, which was generated partly by the educational system, was not realized.

In Latin America the universities have often been a training ground for political leaders, but this did not necessarily mean that they were as progressive and vanguardist in educational, scientific, and technological matters as they were in politics. In an overview of the role of universities in national development in Spanish American countries, John P. Harrison tried to show how "co-gobierno," the institution of student participation in the universities' decision-making bodies which has been a tradition in Latin America since the reform movement of 1918, tended, in fact, to be a conservative force in this specific sense. "I am not aware," he stated, "of any indication that the students differed from their professors in regard to modernizing the curriculum or placing any greater emphasis on research or technical training not tied to the practice of a licensed profession. The most obvious evidence is that thirty years after Cordoba, the internal structure of the few universities where co-gobierno operated did not differ materially from those where control of the university remained in the hands of the catedraticos" (chair holding professors).⁴⁵

Broadly speaking, there seems to have been a correlation in each country between the capacity for reorganization of higher education systems and the possibility of economic expansion. Nowhere was the destruction more sweeping than in Uruguay, where the dismantling of the university coincided with massive migration of the young and educated to other Latin American countries, Europe, and even Australia. Argentina followed a similar, but less radical, process. In Venezuela, where the Universidad Central had been the center for and the basis of the urban guerrillas who shattered the country in the early sixties, the oil revenues allowed for a generous policy of co-optation which brought the radical leadership to legitimate political roles and allowed the universities to remain centers of intense political activities and relatively low academic standards. A similar pattern was followed in Mexico after the 1968 massacre before the Olympic games.

⁴⁵ Harrison, *University versus National Development in Spanish America*, p 13

Scientific research did not necessarily disappear in this process; rather, it often increased in quality and quantity, in spite of the somber predictions of those who directly suffered the blows of political repression. As new manifestations of institution building and program development started to appear in the seventies, it became clear that science and higher education could continue to grow and improve in some Latin American countries, even in the absence of sweeping social and political revolutions, and that they could even be fostered by some of the political regimes that were considered essentially anti-intellectual and anti-scientific.

One change, however, could be observed everywhere: Latin American scientists in the years after the crisis lost much of their traditional European image as savants seeking an intellectual leadership role and adopted the more Americanized one of professional and specialized researcher. It is possible to follow this change in some of its manifestations. The first, which began several years before the crisis became apparent, was to create new, elite institutions that could be developed outside the mainstream of the higher education system and maintain high levels of quality. There are several examples in Brazil: the Instituto Tecnológico da Aeronáutica created in the forties; the Universidade de Brasília in the early sixties; the graduate programs in engineering at the Universidade do Rio de Janeiro (COPPE) in the mid-sixties; and the Universidade de Campinas in the seventies. All these institutions, organized outside the country's higher education system, tended toward a maximum concern for quality and a minimum regard for formal procedures of bureaucratic administration, corporate autonomy, and long-term stability for its faculty. They tended to attract young and aggressive professionals, with little patience for any encumbrances on their work. They were open to international standards of scientific work and provided their students with unusual learning opportunities. All these initiatives eventually suffered institutional crises that derived from their marginality and innovativeness and from the threat they presented to the established institutions. They never entirely disappeared, however, and at their peak they set new patterns of academic excellence which their students and teachers would later try to develop and implement wherever they went. There are several examples in other Latin American countries, including, for instance, the Fundación Bariloche in Argentina and the Universidad Simon Bolívar in Venezuela.

The second manifestation was the attempt to place scientific research as far away as possible from the educational systems. Writing in 1973, Edmundo Fuenzalida suggested that the Chilean university should completely give up the attempt to develop scientific research on its own, since its goals included the transmission of knowledge and skills but not the "production of new knowledge, scientific or otherwise."⁴⁶ In 1971 Amílcar O. Herrera, who believed that research in the universities was an irreplaceable casualty of the years of repression, proposed the establishment of national agencies for scientific and technological planning at the higher political levels, without looking back to the higher education systems as significant actors in this project. The experience of Argentina's National Atomic Commission, which was able to work continuously and successfully in spite of the crisis that shattered the Universidad de Buenos Aires, has certainly inspired these and similar projects. Possibly the most impressive Latin American attempt in this direction is the Instituto Venezolano de Investigaciones Científicas, established in the outskirts of Caracas as a nucleus of pure and high-level scholarship and research. This alternative amounted to looking at scientific research from the standpoint of science and technology, and not from the perspective of the educational system, a shift that almost necessarily led its proponents to the conclusion that divorce was the best solution.⁴⁷

The third approach was to insist on the presence of science at the universities and on its important, but not exclusive, role in social and economic development. Emphasis was to be placed not on intellectual leadership, social awareness, and responsibility, but simply on the benefits of science and technology's products. This view was fully adopted by the Brazilian government when, in 1974, it presented its National Development Plan II (1975-1979). The first part of the plan, entitled "Development and Greatness: Brazil as an Emerging Power," stated that "science and technology, in the present stage of Brazilian society, represented the driving force, the conveyer of the idea of progress and modernization."⁴⁸ In the economic field, technological development will have in the next

⁴⁶ Fuenzalida, "La Universidad Chilena no debe hacer investigación científica." p. 202.

⁴⁷ For Latin American thinking on the matter in the postcrisis years, see Herrera, *Ciencia y Política en América Latina*; Sábato, ed., *El Pensamiento Latinoamericano*; Suárez et al., *Autonomía Nacional o Dependencia*; Boeninger et al., *Desarrollo Científico-Tecnológico y Universidad*. A partial history of the Argentinian atomic energy program may be found in Tanis and Sábato, *Desarrollo de Recursos Humanos en Metalurgia*.

stage the same driving and modernizing role that the emergence of industrialization played in the years after the war.⁴⁸ The plan distinguished technological from fundamental research; for the former, the National Council for Scientific and Technological Development was organized, as an outgrowth of the former National Research Council, and the ambitious National Plan for Scientific and Technological Development was established. The estimation was that \$2 billion would be spent for science and technology during the 1975-1977 period.⁴⁹

This ambitious project was conceived at the end of a period in which Brazil's economy grew at more than 10 percent a year in real terms; the resources poured by the development agencies into the educational and research institutions after the late sixties were more than the latter could absorb and still grow in a balanced way. One of the consequences was the extraordinary growth of new graduate programs and research institutions in Brazil, usually alongside mainstream programs in higher education. Whereas the education system had grown through private, isolated schools, graduate training and research developed at the public universities, and although the increase in enrollments was seen mostly in the social professions, resources tended to go to the technological and exact sciences. The resources were provided directly to research and graduate program leaders, who gained autonomy from the administration of the university and were able to offer much better salaries and working conditions than other institutions in the higher educational system.

The situation was, at least in intention, almost ideal for those who, inspired by the ideas of J. D. Bernal, had for years defended the placement of science and technology at the center of national planning, although it came from a military (and supposedly right-wing) regime and not from a university-led social revolution, as had been expected by many in preceding years.

The oil shock of 1973 marked the beginning of the end of the so-called Brazilian miracle, and the project of national greatness had to be postponed for an indefinite period of time.

⁴⁸ República Federativa do Brasil, Projeto do II Plano Nacional de Desenvolvimento (1975-1979), p 3 (my translation).

⁴⁹ See data in Schwartzman, "Struggling To Be Born," p. 574.

It was replaced by policies of short-term troubleshooting, which made all long-term plans moot. A direct consequence was that programs of higher education and research which were geared to provide human resources and know-how to the big national project were left empty-handed. According to the director of the most outstanding advanced engineering course in this entire effort, located at the Universidade do Rio de Janeiro, his program was initiated in order to graduate a type of engineer who did not exist before, one with a master's or a doctoral degree: "We had the idea that this element, which was necessary for the technological development of the country, was missing from the professional picture." But he adds: "What we expected to happen did not happen. We were throwing a sophisticated product into the market which we believed was required by the country's technological development. We thought that, if we did our part in training M.A.'s and Ph.D.'s in engineering, that is, creative people, they would be absorbed by a country that was really interested in the internal development of technology. But this did not happen."⁵⁰

The crisis at the Graduate Engineering Program of the Universidade do Rio de Janeiro did not take on the dramatic overtones of the interventions at other places and times. Slowly, the program turned its efforts toward the more traditional fields of engineering, mainly civil engineering; it developed its competence in terms of routine technical assistance to the local industry; it trained students well at the master's level, although it enjoyed little success at the doctoral level; and having been created with independent resources and completely outside the administrative arm of the Faculdade de Engenharia, it gradually fell under its control and supervision.

Brazil, with probably the most ambitious program, certainly did not make the only attempt in the past decade to develop scientific research and to offer highly qualified training in Latin American universities; and its frustrations are not unique. A detailed case study of the areas of chemistry and chemical engineering in Venezuela suggests major pessimistic conclusions. "The project of developing a scientific Chemistry and Chemical Engineering in Venezuela was part of the long-term strategy, based on the expansion of the modern industrial sector, that was raised in the forties and redefined in

⁵⁰ Coimbra, quoted in Nunes et al., "Pós-Graduação em Engenharia", chap. 6.

the late fifties." Today, however, "the façade of international cooperation in science and technology can no longer hide the harsh reality lying behind it: the preoccupation of some of the most powerful governmental and corporate actors with using superiority in science and technology to force the poorer countries into a dependent relationship and thus maintain dominance and control. Thus, instead of being a training place for self-reliance, science and technology education constitutes, in fact, a major factor of dependence. The educational system produces overskilled qualified workers in the sense of being highly specialized watchdogs of 'automated factories,' just as deskilled ones, in the sense of being deprived of certain general purpose skills or of traditional innovative capacities that have been downgraded or abandoned.⁵¹

Thus the experiences of Argentina, Chile, Brazil, and Venezuela seem to lead to the same dead end: increased scientific and technological capabilities producing overskilled professionals and increasing dependency. Would these countries be better off and more independent with less science and technology, and with underskilled professionals? This conclusion would be only slightly more absurd than its opposite, that is, that science and technology, within or outside the university, could by themselves determine the socioeconomic development and the self-reliance of a country. The introduction of scientific research in Latin American universities did not play the revolutionary role that so many hoped for and others feared. Nor did it help to solve in a significant way the problems of technological backwardness and dependency which could not be solved through other means. When crisis came, it did not lead to an overall setback in development, but only to a period of more or less violent disruption and to some changes in emphasis, tone, and ideology. The actual effects of the huge investments in graduate training in scientific research in Brazil in the past fifteen years, and of corresponding efforts in other countries, should not be judged solely in terms of their avowed goals, but rather by a series of less obvious and long-range consequences which affected changes in

⁵¹ Vessuri, "Science, University and Graduate Education in Venezuela," p.3.

the perspectives and world outlooks of the thousands of persons who are to play a central position in their countries in the years to come.⁵²

Conclusions

There are no easy solutions to the problems of underdevelopment, inequality, and restricted social and political participation which plague, in different degrees, all Latin American countries. Science, technology', and higher education constitute just a small part of a broader picture, and they do not hold a privileged key to a country's transformation. We can, however, understand their interrelations and their broader social role a little better if we consider a few propositions, some of which follow from the preceding discussion; others are necessary for a proper interpretation.

First, science and technology, regardless of their effective content, play a legitimating role for the claim of autonomy, resources, and social prestige of the Latin American universities. This role, stated by Ben-David and quoted earlier in this essay, applies in Latin America as well as elsewhere.

Second, the institutional instability of Latin American higher education systems makes this ideological role not only a matter of institutional self- defense and protection, but also the basis of a claim for social, political, and ideological leadership that goes far beyond the boundaries of the educational systems. The instability does not result from any supposed Latin American "cultural trait," but rather it stems from the extraordinary rates of urbanization, demographic growth, and modernization these societies have experienced in past decades, with corresponding changes in labor structure, social and political roles, and cultural values and aspirations. Because of these changes, there is a poor fit between the educational system and the labor market, leading to a pervasive

⁵² One of the main determinants of attitude change, in this connection, is the experience of studying abroad. There are innumerable differences among countries in the way this program is implemented, including the return of students to their countries of origin. Argentina and Colombia tend to lose a significant number to the host countries; in Brazil, on the contrary, the return rates are very high. The rate of return depends, among other things, on who pays for study abroad, the proper fit of the students to the host country's educational system, and the attractiveness of work conditions in the country of origin. For a summary of an international study on the subject, see Glaser, *Brain Drain*. The most ambitious program of fellowships for study abroad in Latin America today is provided by Venezuela through the Fundación Gran Mariscal de Ayacucho, which awarded more than 3,000 fellowships for that purpose in 1980. Of these, only a third were for graduate training. See Mauch, "Sudying Abroad.

feeling of frustration and protest among the educated. This situation is not new, but it becomes more serious as higher education systems grow.

Third, the main actors in the higher education system - teachers and students - are unhappy not only with their own institutions but also with the non-academic elites who hold the highest economic and political positions and who are blamed, often with good reason, for the precarious economic and social conditions of the region's population: This is fertile ground, as it was earlier in Europe, for the idea that science and technology can provide better socioeconomic conditions and, incidentally, a new elite.

Fourth, the educational systems have been much more amenable to change and growth than other institutions in Latin America. International cooperation provided well-defined patterns and resources for the creation of the new graduate and research programs; enrollment can grow very quickly, if there is not much concern about educational quality; and new professions can easily be specified on paper and be given supposedly coherent academic programs in the schools. This situation contrasts very sharply with the saturation of the labor market for university-trained people, the decadence of the inflated urban centers, the increasing technological gap between these countries and the industrialized ones, and the growth of capital-intensive industries in Latin America to the detriment of labor-intensive ones. These factors are proving to be very difficult to change.

One consequence of this entire situation is the relative isolation of the educational system and its institutions from the rest of the society. This isolation has both positive and negative consequences. Positively, it eventually allows for the development of competent teaching and research within the higher education system, without the pressures for short-term adaptability to the low requirements of the labor market or the industrial system. Negatively, it produces people trained in obsolete professions, scientific institutions working in outdated subjects with outdated methods, and the substitution of status symbols and behavioral patterns associated with them for proper education and scientific and technological work. In the absence of external checks and controls, it is often difficult to distinguish one from the other.

They are not, however, the same thing. Given the difficult and often dramatic social conditions in many Latin American countries, it would be unfortunate if there were a good fit between the educational system and the scientific community in these countries, on the one hand, and the local conditions on the other. A scientific community working with standards of high quality and a broad view of other possibilities and alternatives for their roles can be a dynamic factor of change and innovation, provided that other conditions are forthcoming.

At the same time, the emphasis placed on the role of scientific research for education, even if properly done, may have a detrimental effect upon other important functions in the areas of general education and professional training which higher education systems might have. In Brazil, the assumption that teaching and research are inseparable has led to the downgrading of professional training without academic degrees, and the creation of still another tier in the educational life for those who enter the higher education system. In practice, the new academic, scientific-minded graduate programs often work as a way of postponing the student's entrance into the labor market and as a filter that partly compensates for the swelling of the undergraduate system. Thus, instead of helping to increase the quality of undergraduate courses, the strengthening of scientific education has helped to bypass and avoid a direct confrontation with the difficult problems of the system. Scientific research is not a panacea for underdevelopment; it is not even a solution to the problems of higher education in its varied implicit and explicit functions. It may be detrimental, as when it loses its content and gains weight and relevance as sheer ideology; but it may also be a factor for change, innovation, and social awareness. What is needed if higher education is to play a better role, in this context, is not just more or less science, but more differentiation and complexity, so that different and frequently contradictory functions can be performed simultaneously. The sociology of science should help to uncover the uniformity that the ideological imagery of modern science often brings to higher education in conditions such as these and should open the way for a richer and less naive understanding of the different modes and possibilities of each.

Policy Implications

What are the policy implications to be drawn from the above? It is clear, first of all, that there is a place for scientific research in some segments of the higher education system in Latin America, as elsewhere. But the role played by research universities today in setting the standards for an entire system in a country⁵³ such as England or the United States, where there is room for institutional competition and innovation, can become detrimental in more rigid and less well-established contexts, where the real contents of research and teaching can easily be replaced by formalistic and bureaucratic impersonations of academic behavior.⁵³ From the standpoint of scientific research, as from that of higher education, it is advisable to limit scientific research to those centers that offer the necessary conditions for doing it, and to try to stimulate other educational values and goals, more related to teaching and community services, in the remaining, larger part of the higher education system.

What are the chances of scientific research really taking hold in a social and cultural context that is without a previous scientific tradition? We may start by brushing aside some extreme misconceptions: there is nothing in the "Latin culture" which is intrinsically inimical to modern science; there is no future in the attempts to develop an "alternative" science that would be more congenial to Latin (or other) cultures and might compete with "Western" science in any significant way; and injections of money, fellowship programs, and visiting professorships are not sufficient, and they may even be counterproductive.

In the underdeveloped countries of today, as in Western Europe centuries ago, modern science was brought in from outside. If we compare the conditions of the growth of science in Latin America with those of the early years of the European universities, we see that in both instances scientific knowledge was perceived as an instrument of social advancement for a relatively marginal group of people, who railed against the entrenched positions of the traditional universities. There are, however, important differences. One is

⁵³ On the role of the research universities as models for higher education systems, see Martin Trow's paper (chap. 5. above). For different interpretations of academic roles in an underdeveloped context, see Ilchman, "Hybrids in Native Soil," pp 85-114.

that the scientific movements in Europe occurred when "science" was relatively simple and the university culture was extremely complex and elitist, based on the mastery of formal logic and the classical languages. This situation permitted the emergence of the amateur scientist, the nonprofessional scientific societies, and the stereotype of the self-taught and slightly crazy, scientific genius which is still today part of international folklore. The contemporary situation is completely reversed: science is an extremely complex activity, requiring the mastery of advanced mathematics, a large literature, and a knowledge of foreign languages, whereas the system of formal education is mass-oriented and tends toward standardization and democratization of access. The Latin American scientist is marginal in the sense that he or she does not follow either the traditional paths of elite education in the traditional professions of law, medicine, and engineering, or the more popular lines of mobility through the new technical or semiprofessional careers. While his early European counterpart participated in a widespread movement for social mobility which was part of the bourgeois and rationalistic revolution, the Latin American scientist is much more isolated as a member of an emerging learned aristocracy.

How the scientist defines his social role, and how this definition is related to his social origins, might be an intriguing research topic for the future. Some scant information available on the Brazilian experience suggests that scientists in the biomedical field tend to be recruited from higher social strata and to define their role as members of the medical profession aristocracy. The physical scientists, on the other hand, are more likely to be recruited from immigrant and upwardly mobile sectors and tend to play a more active role as part of their country's new intelligentsia. Researchers in more applied fields are likely to define themselves as part of emerging new professions, who possess specialized knowledge and who assume appropriate rewards for their work. Social scientists are closer to those in physical science than to other types.⁵⁴

The future of scientific research in this context will depend on the possibilities of institutionalizing science as a permanent and relatively stable professional career, without

⁵⁴ See Schwartzman, "Foreigners in Their Country". See also Becher's approach to the different cultures of academic specialties (chap. 6, above).

depriving it of its aura as a prestigious and socially meaningful activity and without submerging it completely in the mainstream of the higher education teaching population. The aura of prestige and social relevance is necessary' if science is to recruit the best-qualified people and extract from them their greatest efforts, since other gratifications, those of a more material kind offered by other professions, are seldom forthcoming. Moreover, a complete identification with the professional teacher may mean a decreasing involvement with the scientist's academic community. Institutional questions and trade-union and professional (but non-academic) concerns might easily lay claim to most of his or her social commitments and interests, an attachment that might be harmful for scientific work.⁵⁵

Professionalization of science depends on a complex combination of economic, political, and institutional elements; we need, then, to consider the different activities that are usually brought together under the name of "science." The consolidation of technological research, for example, requires an economic and industrial policy that includes a significant volume of autonomous technological development and adaptation, if not creation. These policies may take different shapes, from military buildups to barriers to imported technologies. If this requirement is fulfilled, the next one is to create an educational system that will respond to this demand in terms of qualified education.

More academic and "basic" research may survive much more easily without direct industrial counterparts, if the necessary institutional ingredients are forthcoming. The most obvious one is money for salaries, equipment, office space, and the like. Then, the resources must get to the right people. Because of its limited size and political strength, scientific research tends to be organized as small sections of large educational or governmental institutions, units that receive low priority and are unable to marshal their

⁵⁵ The identification of the university teacher with his union or professional association adds another dimension to Clark's "moving matrix" of academic and institutional affiliation, which is for him a central element in higher education organizations. The distinction between academic and professional associations is not very clear in fields where the professions are defined in terms of their academic contents. In the Latin American context, however, there is an obvious difference between professional associations of lawyers, economists, statisticians, psychologists and the like, which are mainly concerned with the corporative rights of their constituents, and associations in the corresponding academic institutions, which are more oriented toward the advancement of knowledge and the exchange of information. When these two functions are not clearly distinguished, the second tends to suffer. (See Clark's chap. 4 above.)

own criteria of priorities, excellence, and organizational procedures. Brazil has been quite successful, in past decades, in establishing a series of financing institutions that go directly to the scientist or to his department or research group, bypassing the educational or ministerial hierarchy.⁵⁶ The corresponding increase in volume and quality of scientific research, however, combined with budget limitations, is leading to attempts to centralize and coordinate the available resources for research, and such centralization is being perceived, with good reason, as a threat to the previous ability of effectively getting the resources to the right persons.

There is a final and unavoidable political aspect. The development of scientific, technological, and educational prowess takes time and requires institutional stability. These conditions are impossible to meet when society is subject to constant oscillations between social mobilization and political repression, combined with successive and sweeping attempts at institutional reform. This view is not necessarily conservative, since it is obvious that not all forms of stability are conducive to good science and education and there are other social values and goals aside from these. However, it does explain why it is common for people engaged in educational and scientific institution building in contexts of political instability to become exasperated with the futility of their work and to decide that only politics can open the way for everything else. Unfortunately, this is a self-defeating prophecy, since over politicization contributes further to the weakening of the scientific and educational institutions, making them still more vulnerable to political uncertainties.

In short, institution building in the field of scientific research and higher education is a difficult and risky adventure. It deals with activities that are very different from one another, and even conflictive in many ways, but which cannot be fully disconnected. It may have unexpected and contradictory results. And it depends on variables that are usually out of the control of those who try to undertake it. Scientific research, however, is

⁵⁶ These institutions include the Coordenação de Aperfeiçoamento de Pessoal de Ensino Superior (CAPES) in the Ministry of Education; the Finaciadora de Estudos e Projetos (FINEP) and the Conselho Nacional de Desenvolvimento Científico e Tecnológico in the Ministry of Planning; the Fundação de Amparo à Pesquisa in the State of São Paulo; and several permanent, single-purpose research programs and agencies such as the Instituto Nacional de Estudos Pedagógicos, in the field of education, and the Programa Nacional de Pesquisas Econômicas, in economics.

a necessary condition for knowledge, and no human society can willingly renounce it. That is why, like Sisyphus, we must persevere.⁵⁷

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⁵⁷ There are those, of course, who support the notion that both scientific research and higher education should be abandoned as significant goals for Latin America and that they should be replaced by other forms of cultural and emotional participation in society which are more direct, less Westernized, and often more mystic and more hedonistic As the promises of higher education grow dimmer, this view tends to take a stronger hold on better educated people. The importance of this phenomenon, which in a way replicates the counterculture movements of the 1960s in the United States and Europe, is becoming increasingly evident.

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